DOCUMENT RESUME

ED 305 339 SP 031 012

AUTHOR Moore, John O.
TITLE A Comparison of Perceptual Strategies Utilized by Expert and Novice Performers.
PUB DATE Feb 89
NOTE 24p.; Paper presented at the Annual Conference of the Southern District of the American Alliance for Health, Physical Education, Recreation and Dance (Chattanooga, TN, February, 1989)
PUB TYPE Speeches/Conference Papers (150) -- Information Analyses (070)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Athletes; *High Achievement; Perceptual Motor Coordination; *Performance Factors; *Psychomotor Skills; *Team Sports

ABSTRACT

This paper reviews the literature comparing the perceptual strategies of expert and novice sport/skill performers in ball sports to specifically identify where differences exist. The following comparisons were made: (1) experts attend to fewer, somewhat different visual cues than beginners; (2) experts exhibit an ability to utilize advanced anticipatory cues and early flight cues during response preparation; (3) experienced players demonstrate earlier anticipatory movements during competition; and (4) there are inconsistencies in the literature regarding the visual search strategies used by experts and novices. It is suggested that the real difference in perceptual strategies between the two groups was not in their physical search patterns but in their respective abilities to critically attend to available environmental information. (JD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED305339

A COMPARISON OF PERCEPTUAL STRATEGIES UTILIZED BY EXPERT AND NOVICE PERFORMERS

John O. Moore
The University of Tennessee
Knoxville, Tennessee

Refereed Paper Presented at the Annual Conference of the Southern District of the American Alliance for Health, Physical Education, Recreation, and Dance as a Poster Presentation

Chattanooga, Tennessee

February, 1989

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

J.O. Moore

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

SP031 012

A COMPARISON OF PERCEPTUAL STRATEGIES UTILIZED BY EXPERT AND NOVICE PERFORMERS. JOHN O. MOORE, UNIVERSITY OF TENNESSEE, KNOXVILLE.

WHEN BOTH EXPERTS AND NOVICES ARE VIEWED DURING PARTICIPATION IN "BALL SPORTS" (WHITING, 1969), PERFORMANCE DIFFERENCES ARE READILY APPARENT. EXPERTS GENERALLY MOVE MORE EFFICIENTLY AND SEEM TO POSSESS "ALL THE TIME IN THE WORLD" TO RESPOND (ANNETTE & KAY, 1956; JONES & MILES, 1978). THIS ENHANCED ABILITY OF SKILLED PLAYERS TO ANTICIPATE UPCOMING MOVEMENTS (BARTLETT, 1947) IS NOT A RESULT OF NEUROLOGICAL OR SENSORY SPECIALIZATION (I.E., HARDWARE), BUT IS DUE TO MODIFICATIONS IN "SOFTWARE" OR INFORMATION PROCESSING ABILITY (STARKES & DEAKIN, 1984; STARKES, 1987). THE PURPOSE OF THIS PAPER WAS TO REVIEW THE LITERATURE COMPARING THE PERCEPTUAL STRATEGIES OF EXPERT AND NOVICE SPORT/SKILL PERFORMERS TO SPECIFICALLY IDENTIFY WHERE DIFFERENCES EXIST. THE REVIEW YIELDED SEVERAL CONSISTENT CONCLUSIONS AND ALSO REVEALED AN AREA WHERE THE LITERATURE IS CURRENTLY CONFLICTING. FIRST, EXPERTS ATTEND TO FEWER, SOMEWHAT DIFFERENT VISUAL CUES THAN BEGINNERS. ALTHOUGH ONLY LIMITED RESEARCH HAS BEEN CONDUCTED IDENTIFYING THE EXACT CUES UTILIZED, IT APPEARS THAT EXPERIENCED PLAYERS GATHER THE MOST CRITICAL INFORMATION FROM THE OPPONENT'S IMPLEMENT (E.G., RACQUET OR STICK) AND MOST PROXIMAL LIMB TO THAT IMPLEMENT (ABERNETHY & RUSSELL, 1987 A & B). SECOND, EXPERTS EXHIBIT AN ABILITY TO UTILIZE ADVANCED ANTICIPATORY CUES AND EARLY FLIGHT CUES DURING RESPONSE PREPARATION WHILE NOVICES FOCUS ON LATER FLIGHT CUES FOR CONFIRMATION BEFORE RESPONDING (CALMELS & FIORITO, 1979; ABERNETHY & RUSSELL, 1987A). THIRD, EXPERIENCED PLAYERS DEMONSTRATE EARLIER ANTICIPATORY MOVEMENTS DURING COMPETITION WHEN COMPARED TO PHYSICALLY MATCHED NOVICES (HOWARTH ET AL., 1984). EXPERTS SEEM TO RELY GREATLY ON ADVANCED INFORMATION IN MAKING RESPONSE

DECISIONS. AND FOURTH, INCONSISTENCIES APPEAR REGARDING THE VISUAL SEARCH STRATEGIES USED BY EXPERTS AND NOVICES. SEVERAL AUTHORS (E.G., MOURANT & ROCKWELL, 1972; BARD & FLEURY, 1976) SUGGESTED THAT THE TWO GROUPS DIFFERED SIGNIFICANTLY IN TERMS OF SCAN PATHS (I.E., EXPERTS USE FEWER AND SHORTER FIXATIONS). ABERNETHY & RUSSELL (1987B), IN A MORE IN-DEPTH STUDY, CONTENDED THAT THE SAME GENERAL SEARCH SEQUENCES (I.E., PROXIMAL TO DISTAL) ARE USED BY PLAYERS AT BOTH LEVELS. ABERNETHY & RUSSELL (1987B) AND BARD, FLEURY & GOULET (1987) FURTHER SUGGESTED THAT THE REAL DIFFERENCE IN PERCEPTUAL STRATEGIES BETWEEN THE TWO GROUPS WAS NOT IN THEIR PHYSICAL SEARCH PATTERNS, BUT IN THEIR RESPECTIVE ABILITIES TO CRITICALLY ATTEND TO AVAILABLE ENVIRONMENTAL INFORMATION.

SKILLED PERFORMERS IN "BALL SPORTS" (WHITING, 1969) DIFFER FROM UNSKILLED PLAYERS EVEN DURING QUICK OBSERVATIONS BECAUSE WHILE PLAYING, EXPERTS APPEAR TO HAVE "ALL THE TIME IN THE WORLD" TO RESPOND, OFTEN TO EXTREMELY FAST-PACED GAME SITUATIONS (ANNETT & KAY, 1956; JONES & MILES, 1978). ALLARD AND BURNETT (1985) SUGGEST THAT THIS ENHANCED ABILITY IS NOT SIMPLY DUE TO AN INNATELY SPECIALIZED NERVOUS OR MUSCULAR SYSTEM, BUT RATHER FROM A MORE EFFECTIVE ATTENTIONAL PROCESSING PROCEDURE. STARKES & DEAKIN (1984) AND STARKES (1987) CONCLUDED THAT THE ENHANCED ABILITY OF HIGHLY SKILLED PLAYERS TO ANTICIPATE UPCOMING EVENTS IS DUE TO "SOFTWARE" OR INFORMATION PROCESSING ABILITIES, NOT SIMPLY NEUROLOGICAL OR SENSORY SPECIALIZATION, "HARDWARE." WELFORD (1968) STATED THAT HUMANS HAVE A "LIMITED CHANNEL PROCESSING CAPACITY" WHICH RESTRICTS THE NUMBER OF BITS OF INFORMATION THAT CAN BE HANDLED AT ANY GIVEN TIME. THIS LIMITATION HAS BEEN SHOWN TO BE TRUE EVEN THOUGH MANY STIMULI (INTERNAL AND EXTERNAL) ARE SIMULTANEOUSLY IMPINGING UPON THE INDIVIDUAL. WITHIN THE ENVIRONMENT, MANY OF THESE STIMULI ARE IRRELEVANT AND/OR REDUNDANT. THE BEGINNING LEVEL PLAYER (FITTS, 1964) IS NOT AWARE OF THE REDUNDANCIES AND ATTENDS TO FAR TOO MANY CUES IN THE DISPLAY. THIS METHOD IS INEFFICIENT AND USUALLY INEFFECTIVE. THE SKILLED PLAYER, HOWEVER, IN FITTS' AUTONOMOUS STAGE OF LEARNING, SEES THE SITUATION AS MORE PREDICTABLE, DISREGARDS USELESS INFORMATION, AND ATTENDS TO FEWER, MORE SALIENT CUES (ANNETT & KAY, 1956; ABERNETHY & RUSSELL, 1987A).

IN SKILLS OR SPORTS CLASSIFIED BY POULTON (1957) AS "OPEN," TIMING IS A CRITICAL FACTOR. PERFORMER'S RESPONSES MUST MATCH ENVIRONMENTAL DEMANDS (E.G., BALL SPEED AND LOCATION), WITH CONSIDERATION FOR THEIR OWN CENTRAL PROCESSING AND MOVEMENT TIME REQUIREMENTS TAKEN INTO CONSIDERATION. IN ORDER TO FACILITATE THIS MATCH, PLAYERS MUST NOT

ONLY ATTEND TO THE RELEVANT CUES, BUT MUST LOCATE THEM QUICKLY DURING THE EARLY PHASE OF PERFORMANCE (BARD & FLEURY, 1976; JONES & MILES, 1978). GIVEN THAT THERE IS A LIMITED TIME WITHIN WHICH THE CORRECT STEP, SHOT, SWING, ETC. WILL BE SUCCESSFUL, PLAYERS WHO ARE PREPARED TO RESPOND EARLY WILL BE AT AN ADVANTAGE (HASKINS, 1965).

A MODERATE AMOUNT OF RESEARCH HAS BEEN CONDUCTED COMPARING THE "PERCEPTUAL STRATEGIES" OF EXPERT AND NOVICE SPORT PERFORMERS TO SPECIFICALLY IDENTIFY WHERE THE DIFFERENCES EXIST. THE LITERATURE HAS YIELDED SEVERAL CONSISTENT CONCLUSIONS: (A) EXPERTS ATTEND TO SOMEWHAT DIFFERENT CUES THAN BEGINNERS (ABERNETHY & RUSSELL, 1987A; SALMELA AND FIORITO, 1979; ANNETT & KAY, 1956); (B) EXPERTS UTILIZE ADVANCED ANTICIPATORY CUES FOR PREDICTION OF OPPONENTS' SHOTS/PLAYS MORE SO THAN DO NOVICES (ABERNETHY & RUSSELL, 1984; JONES & MILES, 1978); AND (C) EXPERIENCED PLAYERS DEMONSTRATE EARLIER ANTICIPATORY MOVEMENTS DURING COMPETITION THAN DO PHYSICALLY MATCHED NOVICES (HOWARTH ET AL., 1984). IN CONTRAST, INCONSISTENCIES APPEAR REGARDING THE VISUAL SEARCH STRATEGIES USED BY EXPERT AND NOVICE PLAYERS. SEVERAL AUTHORS (E.G., BARD & FLEURY, 1976; MOURANT & ROCKWELL, 1972) CONTEND THAT THE TWO GROUPS DIFFER SIGNIFICANTLY IN TERMS OF SCAN PATHS, WHILE OTHERS, IN MORE RECENT STUDIES (ABERNETHY & RUSSELL, 1987B; BARD, FLEURY, & GOULET, 1987) SUGGEST THAT THE SAME GENERAL SEARCH SEQUENCES (I.E., PROXIMAL TO DISTAL) ARE USED BY PLAYERS AT BOTH SKILL LEVELS. THUS, THE REAL DIFFERENCE IN PERCEPTUAL STRATEGIES BETWEEN THE TWO GROUPS IS NOT IN THEIR PHYSICAL SEARCH PATTERNS, BUT IN THEIR RESPECTIVE ABILITIES TO MAKE USE OF AVAILABLE ENVIRONMENTAL INFORMATION.

Visual Search Patterns

Recent findings in the visual search strategy literature suggest that the scan paths exhibited by experts and novices while viewing open sport performance do not substantially differ (Abernethy & Russell, 1987b; Bard, Fleury, & Goulet, 1987; Goulet, Fleury, & Bard, 1989). However these current findings are in contrast with the results found in a majority of previous visual search studies (Bard & Fleury, 1976; Megaw & Richardson, 1979; Mourant & Rockwell, 1972; Schoonard, Gould, & Miller, 1973; Stern & Bynum, 1970). Differences in research protocol and/or data collection/analysis techniques due to advancements in eye movement recording equipment may account for some of the discrepancies. In addition, the recent search strategy studies employ more dynamic visual situations than static situations, i.e., watching films or live performance instead of watching slides, which may further explain inconsistencies in the findings.

Abernethy & Russell (1987b) measured the visual search characteristics of 15 expert and 16 novice badminton players as they performed a film test designed to assess anticipatory cue usage. From the film task, it was determined that experts could: (a) extract earlier visual cues than novices; and (b) make use of cues associated with both the racquet and proximal arm, while novices appear only to attend to the racquet. These differences in information extraction ability, however, were not reflected by differences in visual search characteristics. Both skill levels displayed virtually the same search strategies in terms of the location, duration, and sequence of fixations. These findings suggested that expert-novice differences in perceptual strategies are apparently the result of an enhanced information extraction ability exhibited by experts.

GOULET, FLEURY, & BARD (1988) CONDUCTED TWO STUDIES INVESTIGATING THE VISUAL SEARCH STRATEGIES AND RESPONSE DECISION ACCURACY OF 15 EXPERT AND 14 NOVICE TENNIS PLAYERS AS THEY PERFORMED A TEMPORAL OCCLUSION FILM TASK WHICH SIMULATED RETURNING A SERVE IN TENNIS. THE SERVE BEING VIEWED WAS DIVIDED INTO THREE PHASES: (A) RITUAL, (B) PREPARATORY, AND (C) EXECUTION, WITH THE NUMBER OF VISUAL EXCHANGES OCCURING BETWEEN 10 PREDETERMINED AREAS DURING EACH PHASE BEING CALCULATED. IN EXPERIMENT 1, IT WAS DETERMINED THAT ALTHOUGH THERE WERE SOME SIGNIFICANT DIFFERENCES BETWEEN THE SKILL LEVELS IN SEARCH ORGANIZATION, BOTH GROUPS GENERALLY USED THE SAME CUES. EXPERIMENT 2 REVEALED THAT NOVICE PLAYERS USE THE RITUAL PHASE TO EXTRACT SALIENT INFORMATION, WHILE EXPERTS BENEFIT GREATLY FROM CUES AVAILABLE DURING THE INITIAL PART OF THE EXECUTION PHASE.

ALTHOUGH IT IS NOT POSSIBLE TO ASCERTAIN WHAT THE INDIVIDUAL IS ACTUALLY "ATTENDING" TO THROUGH THE USE OF EYE-MOVEMENT RECORDING DEVICES ALONE (NOTON & STARK, 1971; ABERNETHY & RUSSELL, 1987B). A NUMBER OF FINDINGS HAVE SUGGESTED THAT THERE ARE AT LEAST SOME PHYSICAL DIFFERENCES BETWEEN EXPERTS AND NOVICES IN VISUAL SEARCH STRATEGIES DURING PERFORMANCE. HOWEVER, MORE RECENT RESEARCH STUDIES (ABERNETHY & RUSSELL, 1987B; BARD, FLEURY, & GOULET, 1987; GOULET, FLEURY & BARD, 1988) HAVE PROPOSED THAT THE DIFFERENCES ARE NOT IN THE PHYSICAL SCAN PATHS UTILIZED, BUT IN THE SIGNIFICANCE GIVEN TO THE INFORMATION ACQUIRED. DEVELOPMENT OF SENSITIVE RECORDING EQUIPMENT DURABLE ENOUGH TO BE WORN DURING ACTUAL SPORT PERFORMANCE, IN CONJUNCTION WITH DETAILED SELF-REPORTS WOULD GREATLY ENHANCE KNOWLEDGE IN THE AREA.

Relevant Cue Identification

Allard and Burnett (1985) completed a review discussing a variety of sport skills from the perspective of the expert player: (a) perceptual strategies used by experienced players were generally shown to be a function of the speed and complexity of the game being played; (b) expert chunking ability was shown to be related to task experience; (c) experts took in more relevant information in shorter time periods; and (d) experienced performers used knowledge of the game to decode the current situation before responding. Allard & Burnett (1985) conducted a study in which experienced and novice basketball players grouped 30 basketball-related pictures into what they thought were sensible categories. The expert players used significantly more distinct categories than the beginners, who appeared to group the pictures haphazardly. This suggested that the beginners could not identify relevant grouping cues; while the advanced players were consistent in their choices and readily selected the important stimuli as they better understood the demands of the situation. This ability enabled the experienced players to make more frequent correct decisions earlier. This ability was also exemplified in Burnett's (1983) study involving two levels of softball players tested on relevant and distracting cues while batting. The expert players attended to the critical cues (i.e., pitcher's wrist) and were not distracted by the irrelevant ones. Allard and Burnett's (1985) review suggested that experienced players were systematically different from beginners in their processing and analysis of sporting situations.

Salmela and Fiorito (1979) examined the effects of three different visual occlusion conditions on the ability of youth ice hockey goalies (N=54) to predict the direction of two different types

OF SHOTS ON GOAL. SUBJECTS WATCHED A FILM TAKEN FROM THE GOALIE'S PERSPECTIVE AS AN OFFENSIVE PLAYER HIT EITHER A SLAP SHOT OR WRIST SHOT FROM 40 FEET INTO ONE OF FOUR DESIGNATED CORNERS OF THE TARGET. THREE REPLICATIONS OF HITTING BOTH TYPES OF SHOTS INTO EACH CORNER WERE FILMED FOR A TOTAL OF 24 SHOTS. THE FILM WAS EXPERIMENTALLY MANIPULATED SO THAT FOR EACH SEQUENCE OF SHOT TYPE AND CORNER, 2, 4, AND 8 FRAMES WERE OCCLUDED BEFORE STICK-PUCK CONTACT. AFTER EACH SHOT WAS PRESENTED, THE FILM WAS STOPPED AND SUBJECTS WERE ASKED TO VERBALIZE TO WHICH CORNER THEY BELIEVED THE SHOT WAS DIRECTED, AND TO REPORT THEIR RESPONSE CONFIDENCE (1-5). ANALYSIS OF THE DATA REVEALED THAT: (A) THE TOTAL SUCCESS CATEGORY WAS PREDICTED 38.6% OF THE TIME; (B) THE SIDE OF THE SHOT (27.2%) WAS PREDICTED ACCURATELY MORE OFTEN THAN HEIGHT (19.0%); AND (C) THERE WAS A SIGNIFICANT DIFFERENCE IN OVERALL PATTERNS OF RESPONSES ANALYZED BY THE THREE OCCLUSION PERIODS, $p < .01$). THE TOTAL NUMBER OF CORRECT RESPONSES DECREASED AS THE AMOUNT OF OCCLUSION INCREASED, WHILE THE SIDE OF THE SHOT CONTINUED TO BE PREDICTED MORE ACCURATELY THAN HEIGHT IN A MORE STABLE MANNER ACROSS ALL CONDITIONS. THE WRIST SHOT RESULTED IN A SIGNIFICANTLY HIGHER NUMBER OF CORRECT DECISIONS THAN DID SLAP SHOTS, $p < .05$, WHICH SUGGESTED THAT RELEVANT INFORMATION WAS AVAILABLE FROM THE DISPLAY, I.E., THE OFFENSIVE PLAYER'S IDIOSYNCRATIC MOVEMENTS, BEFORE ACTUAL STICK-PUCK CONTACT. THIS SEEMS REASONABLE GIVEN THE HIGH RATE OF PUCK SPEED IN FLIGHT AND THE SUCCESS OF MOST GOALIES IN STOPPING OR AT LEAST DEFLECTING A MAJORITY OF SHOTS. THE FINDINGS ALSO SUGGESTED THAT FOR MOST EFFECTIVE PERFORMANCE, GOALIES MIGHT INITIALLY ATTEND TO THE CUES RELATED TO THE APPROPRIATE SIDE OF THE GOAL, THEN, INSTANTANEOUSLY, ATTEND TO HEIGHT CUES. SUPERIOR PREDICTION OF WRIST SHOT DIRECTION WAS BOTH OBJECTIVELY AND SUBJECTIVELY (I.E., CONFIDENCE SCALE) REPORTED.

THE GOALIE REMARKED THAT THE SHOOTER USED A UNIQUE SHOT PREPARATION MOVEMENT AND "TELEGRAPHED" HIS INTENTIONS WHEN HITTING A WRIST SHOT.

ABERNETHY AND RUSSELL (1987A) CONDUCTED TWO STUDIES TO COMPARE THE PERCEPTUAL STRATEGIES USED BY EXPERIENCED AND NOVICE RACQUET SPORT PLAYERS: (A) THE INITIAL STUDY INVOLVING TEMPORAL ANTICIPATORY CUES, AND (B) THE SECOND EXAMINING SPATIAL CUES. SUBJECTS (N=55) CONSISTED OF 20 NATIONAL-LEVEL BADMINTON PLAYERS, EXPERT GROUP, AND 35 UNDERGRADUATE PHYSICAL EDUCATION MAJORS, NOVICE GROUP. THE EXPERIMENTAL TASK REQUIRED SUBJECTS TO VIEW A BADMINTON FILM RECORDED FROM A RECEIVING PLAYER'S PERSPECTIVE AS AN OFFENSIVE PLAYER HIT A VARIETY OF SHOTS IN HIS/HER DIRECTION. THE SHOTS WERE DERIVED FROM EIGHT POSSIBLE CATEGORIES (E.G., DROP SHOT, SMASH) AND CONSISTED OF FOUR REPLICATIONS OF EACH FOR A TOTAL OF 32 STROKES. EACH STROKE WAS RANDOMLY PRESENTED UNDER FIVE DIFFERENT VIEWING LENGTHS FOR A TOTAL OF 160 TRIALS. THE OCCLUSION OF THE DISPLAY OCCURRED AT EACH OF THE FOLLOWING TIMES: (T1) FOUR FRAMES PRIOR TO RACQUET-BIRDIE CONTACT; (T2) 2 FRAMES PRIOR TO CONTACT; (T3) AT POINT OF CONTACT; (T4) 2 FRAMES AFTER CONTACT; AND (T5) NO OCCLUSION.

SUBJECTS WERE INSTRUCTED TO VIEW THE FILM AS IF THEY WERE RECEIVING THE BIRDIE IN AN ACTUAL GAME AND TO RECORD THE ESTIMATED LANDING POSITION. THE ANSWER SHEET WAS A SCALED VERSION OF A BADMINTON COURT AND RECORDS WERE TO BE MADE DURING THE INTERTRIAL INTERVAL. THREE TYPES OF DISCREPANCY ERRORS, PREDICTED VERSUS ACTUAL LANDING, WERE RECORDED: (A) LATERAL ERROR; (B) DEPTH ERROR; AND (C) RADIAL ERROR. RESULTS INDICATED THAT A SIGNIFICANT INTERACTION WAS FOUND BETWEEN SKILL LEVEL AND TEMPORAL OCCLUSION CONDITIONS, $p < .05$. EXPERT PLAYERS MADE MORE ACCURATE PREDICTIONS ON UPCOMING STROKES THAN DID BEGINNERS ON ALL CONDITIONS, EXCEPT T1. PHASES T2-T3 WERE MOST

IMPORTANT FOR DETERMINING DEPTH INFORMATION, WHILE PHASES T2-T4 WERE CRITICAL IN GAINING DIRECTIONAL INFORMATION. THE UNIQUE ABILITIES OF THE EXPERIENCED PLAYERS, HOWEVER, TO EXTRACT BOTH DIRECTIONAL AND DEPTH INFORMATION BETWEEN THE EARLIEST STAGES (T1-T2) WAS SUGGESTED AS THE MOST CRUCIAL DIFFERENCE BETWEEN THE TWO GROUPS. THIS ENHANCED PERCEPTUAL ABILITY MAY ALLOW EXPERT PLAYERS TO BEGIN THEIR "RESPONSE INITIATION" AT AN EARLIER TIME. IT WAS ALSO IDENTIFIED THAT ADVANCED CUES AID IN DETECTING BIRDIE-FLIGHT DEPTH, WHEREAS SHOT DIRECTION IS RESOLVED USING EARLY FLIGHT CUES.

THE SECOND EXPERIMENT DEALT WITH DIFFERENCES BETWEEN THE TWO GROUPS IN THEIR USAGE OF SPATIAL CUES. THE SAME SUBJECTS, DESIGN, AND EXPERIMENTAL PROCEDURE WERE USED, BUT THE OCCLUSIONS WERE SPATIAL RATHER THAN TEMPORAL. OPAQUE MATS WERE USED TO BLOCK OUT SELECTED PARTS OF THE DISPLAY ON EACH CONDITION AS THE FILM ADVANCED AS FAR AS RACQUET-BIRDIE CONTACT BEFORE STOPPING. THE FIVE OCCLUSION CONDITIONS WERE: (E1) PLAYER'S ARM AND RACQUET; (E2) PLAYER'S RACQUET ONLY; (E3) PLAYER'S FACE AND HEAD; (E4) PLAYER'S LOWER BODY; AND (E5) AN UNIMPORTANT PART OF THE BACKGROUND. THE LAST CONDITON (E5) SERVED AS A CONTROL TO SEE IF THE PRESENCE OF THE MAT ALONE RESULTED IN PERFORMANCE DECREMENT. UPON EXPERIMENTAL COMPLETION, SUBJECTS WERE QUESTIONED ABOUT THE REALITY OF THE TESTING SITUATION AND THEIR OWN CUE UTILIZATION STRATEGIES. A DEFINITE DIFFERENCE WAS SUGGESTED CONCERNING SPATIAL CUES USED BY EXPERTS AND NOVICES. P .05. THE EXPERTS WERE SHOWN TO ATTEND TO THE RACQUET AND THE MOST PROXIMAL LIMB IN GATHERING ADVANCED INFORMATION, WHILE THE BEGINNERS WATCHED ONLY THE RACQUET. NEITHER MADE USE OF THE HEAD, FACE, OR LOWER BODY. THE USE OF THE OF THE PLAYING SIDE ARM AS A CUE IS ADVISABLE BECAUSE IT GIVES INFORMATION EVEN EARLIER THAN THE RACQUET.

A STUDY BY DAY (1980) INVOLVING ADVANCED JUNIOR TENNIS PLAYERS INDICATED THAT EXPERTS POSSESSED AN UNDERSTANDING OF STROKE DEPTH AND WERE ABLE TO "READ" OR PREDICT IMPENDING SERVES/SHOTS. THE INVESTIGATION WAS CONDUCTED BY PLACING A VISOR ON THE SUBJECT WHICH WAS ACTIVATED BY A PRESSURE SWITCH ON THE HITTER'S RACQUET. THE VISOR OBSCURRED VISION AT THE POINT OF BALL-RACQUET CONTACT AND THE SUBJECT WAS REQUIRED TO PREDICT LANDING POSITION OF THE BALL BASED ON LIMITED VISUAL INFORMATION. RESULTS INDICATED THAT ADVANCED PLAYERS ATTEND TO: (A) OPPONENT'S RACQUET FACE ANGLE; (B) POSITION OF BALL TOSS; (C) LINE OF SHOULDERS; AND (D) WEIGHT TRANSFER.

IN SUMMARY, ALTHOUGH THERE IS CONSIDERABLE LITERATURE IDENTIFYING THE FACT THAT SKILLED AND NOVICE PERFORMERS ATTEND TO DIFFERENT AMOUNTS OF AVAILABLE STIMULI (E.G., ANNETT & KAY, 1956; GENTILE, 1972), THERE HAS NOT BEEN MUCH RESEARCH DIRECTED TOWARD IDENTIFYING TO WHICH SPECIFIC CUES EXPERIENCED PLAYERS ATTEND. IT APPEARS THAT FOR EXPERTS, WATCHING NOT ONLY THE IMPLEMENT'S CHARACTERISTICS (E.G., ANGLE AND MOVEMENT DIRECTION/SPEED), BUT ALSO THE PERFORMER'S LIMB MOST PROXIMAL TO THE IMPLEMENT IS CRITICAL FOR CUE DETECTION. SCULLY AND NEWELL (1985) STATED THAT RECOGNIZING CHANGES IN THE RELATIVE SPEED OF THE PARTS OF THE LIMB TO EACH OTHER AND TO THE REST OF THE BODY IS A FURTHER CUE DETECTION STRATEGY TO BE USED DURING TEACHING AND PERFORMANCE. THE IDENTIFICATION OF DIRECTIONAL FLIGHT CUES WAS SHOWN TO BE IMPORTANT (SALMELA & FIORITO, 1979) AND A FUNCTION OF EXPERIENCE (ABERNETHY & RUSSELL, 1987).

Anticipatory Cue Utilization

Haskins (1965) attempted to design and implement a training film for tennis players which would facilitate recognition of the direction of a tennis return. The training film consisted of a player hitting 54 examples of various shots toward the camera which was stationed at the baseline. The film was modified by ending the view of the shot one frame after and eight frames after impact, respectively. The response recording device for subjects was a five button control panel positioned from left to right by which the subjects recorded their perceived direction of each shot. The panel was electronically connected to the film and recorded the time between the beep and subject's response to ball direction. To validate the use of the film, subjects were filmed from behind in slow motion as they initiated a rally with another player in the far court and responded to the return. Fifteen clear trials of each subject were recorded and the film was broken down to determine time between point of impact by opposing player and subject's first movement in the correct direction in response to the shot. Response time was the mean of all shots recorded.

Eleven university faculty and students with some prior tennis experience served as subjects. All subjects performed a 15-shot filming session, participated in a training session (i.e., viewing and responding to a series of one-frame and eight-frame films), and then took part in another filming session. All subjects reduced their response times between the first and second filmings. The group means in terms of number of frames occuring between first impact and response were 12.13 before training and 8.84 after training ($t=6.25$, $df=10$, $p < .001$). The results suggested that the use of the training

FILM AIDED IN DEVELOPING PLAYER'S RESPONSE TIME. THIS IS DESIRABLE IF THE FASTER THE PLAYER RESPONDS/MOVES, THE MORE LIKELY HE/SHE IS TO GET INTO PROPER HITTING POSITION. ALTHOUGH THE SPECIFIC CUES ATTENDED TO BY THE PLAYERS WERE NOT IDENTIFIED IN THE STUDY, IT APPEARS THAT THE PRECONTACT MOVEMENTS OF THE OPPONENT (I.E., SETTING UP) AND EARLY BALL FLIGHT CUES ARE INDEED IMPORTANT.

JONES AND MILES (1978) LOOKED AT THE ABILITIES OF EXPERIENCED (N=32) AND NOVICE (N=60) LAWN TENNIS PLAYERS IN DETERMINING THE LANDING POINT OF A SERVED BALL UNDER THREE VIEWING CONDITIONS. SUBJECTS WATCHED A FILM FROM THE RECEIVER'S STANDPOINT AS A NATIONAL-LEVEL PLAYER HIT 24 LEGAL SERVES; EIGHT SERVES WENT DOWN THE CENTER LINE (X), EIGHT DOWN THE MIDDLE OF THE SERVICE COURT (Y), AND EIGHT DOWN THE OUTSIDE LINE OF THE SERVICE COURT (Z). THE EXPOSURE TIME OF EACH SHOT WAS MANIPULATED UNDER THE THREE VIEWING CONDITIONS: (A) EIGHT FRAMES AFTER BALL-RACQUET CONTACT; (B) THREE FRAMES AFTER CONTACT; AND (C) ONE FRAME BEFORE IMPACT. THE THREE VIEWING CONDITIONS AS WELL AS THE THREE SERVICE POSITIONS WERE PRESENTED RANDOMLY WITH ALL SUBJECTS RECEIVING EXPOSURE IN THE SAME ORDER. NO FEEDBACK WAS GIVEN. SUBJECTS WERE GIVEN A SHEET REPRESENTING A COURT AND ASKED TO RECORD AN X, Y, OR Z AFTER EACH SHOT DEPENDING UPON WHERE THEY ESTIMATED THE BALL WOULD LAND. ANALYSIS OF VARIANCE RESULTS INDICATED SIGNIFICANT OVERALL DIFFERENCES IN THE THREE CONDITIONS ($F(2,273) = 20.26$; $P < .001$). THE AVAILABILITY OF TIME TO VIEW THE BALL AFFECTED THE DEGREE TO WHICH SUBJECTS RESPONDED CORRECTLY. A FURTHER ANOVA (GROUPS X CONDITIONS X SUBJECTS) REVEALED A SIGNIFICANT GROUP X CONDITIONS INTERACTION ($P < .01$) WHICH INDICATED THAT THERE WERE DIFFERENCES BETWEEN EXPERTS AND NOVICES IN THEIR ABILITY TO EFFECTIVELY USE POTENTIAL INFORMATION INCLUDED IN OPPONENT'S SERVICE MOVEMENTS. AS TIME OF OCCLUSION

INCREASED, THE EXPERTS PERFORMED MORE ACCURATELY. SOME EXPERTS ACHIEVED SCORES SIGNIFICANTLY BETTER THAN CHANCE ON CONDITION C WHICH SUGGESTS THAT THEY MADE USE OF OPPONENT'S EARLY MOVEMENTS (I.E., BEFORE BALL-RACQUET CONTACT) AS RELEVANT CUES.

ISAACS AND FINCH (1983) ATTEMPTED TO DETERMINE IF THERE WERE DIFFERENCES IN THE ABILITIES OF COLLEGE AGE BEGINNING (N=34) AND INTERMEDIATE (N=16) TENNIS PLAYERS TO PREDICT THE PLACEMENT OF A TENNIS SERVE UNDER ONE OF FOUR RESTRICTED VIEWING CONDITIONS. SUBJECTS WATCHED A FILM FROM THE RECEIVER'S PERSPECTIVE AS A PROFESSIONAL PLAYER SERVED INTO THE DEUCE COURT. THE SERVICE COURT WAS MARKED OFF INTO TWELVE EQUAL SECTIONS FOR SCORING PURPOSE. THE FOUR VIEWING CONDITIONS CONSISTED OF OCCLUDING VISION AT ONE OF THE FOLLOWING TIMES: (A) 10 MS BEFORE BALL-RACQUET CONTACT; (B) AT CONTACT; (C) 15 MS AFTER CONTACT; AND (D) 30 MS AFTER CONTACT. ALL CONDITIONS ALLOWED FOR VIEWING SERVER STANCE, BALL TOSS, AND AT LEAST A PORTION OF THE SWING. SUBJECTS PERFORMED TWELVE TRIALS AS THE CONDITIONS WERE RANDOMLY PRESENTED, AND RECORDED THEIR PREDICTIONS ON A SCORE SHEET WHICH WAS A SCALED VERSION OF THE EXPERIMENTAL DEUCE SERVICE COURT. SUBJECTS HAD FIVE SECONDS BETWEEN EACH TRIAL TO RECORD LANDING PREDICTIONS. THE DATA WERE ANALYZED AS MEAN CORRECT RESPONSES FOR LATITUDINAL, LONGITUDINAL, AND EXACT BALL PLACEMENT. A 2x4 FACTORIAL ANOVA WAS PERFORMED ON EACH OF THE MEASURES. THE RESULTS INDICATED: (A) MORE EXPERIENCED PLAYERS COULD PREDICT LATITUDINAL DIRECTION OF THE TENNIS SERVE SIGNIFICANTLY BETTER THAN THE BEGINNERS; (B) AS THE VIEWING TIME INCREASED, BOTH GROUPS WERE MORE SUCCESSFUL IN PREDICTING THE LATITUDE AND LONGITUDE OF THE SERVES; AND (C) NO SIGNIFICANT DIFFERENCES FOR EXACT BALL PLACEMENT WERE DERIVED. NEITHER GROUP OF PLAYERS DEMONSTRATED AN ABILITY TO EXTRACT MOVEMENT CUES FROM THE SERVE.

ABERNETHY AND RUSSELL (1984) DEVELOPED A FRAMEWORK FOR SECTIONING THE TEMPORAL SEQUENCE OF EVENTS INVOLVED IN DECISION MAKING WHILE PARTICIPATING IN A FAST BALL GAME (E.G., CRICKET). TOTAL RESPONSE TIME WAS DIVIDED INTO THREE PARTS: (1) VIEWING TIME (I.E., ELAPSED TIME NECESSARY TO ANALYZE DISPLAY AND CHOOSE A RESPONSE); (2) LATENCY TIME (I.E., FROM STROKE SELECTION TO INITIATION [SRT]); AND (3) MOVEMENT TIME (I.E., DURATION OF RESPONSE PHASE). THIS FRAMEWORK WAS USED WHEN CONDUCTING TWO EXPERIMENTS INVOLVING THE DIFFERENCES IN GENERAL RESPONSE SELECTION ABILITIES AND ADVANCED CUE UTILIZATION OF TWO LEVELS OF CRICKET PLAYERS (N=18). GROUPS 1 AND 2 WERE HIGHLY SKILLED PLAYERS, WHILE GROUP 3 POSSESSED LOWER SKILL LEVELS. THE EXPERIMENTAL TASK IN BOTH STUDIES WAS TO WATCH A FILM TAKEN FROM A BATTER'S PERSPECTIVE AS A CRICKET BOWLER DELIVERED EIGHT SELECTED PITCHES. SIX BLOCKS OF THE EIGHT PITCHES WERE SHOWN WITH PITCH ORDER BEING RANDOMIZED.

IN EXPERIMENT 1, THE BOWLER'S RUN-UP THROUGH COMPLETE BALL FLIGHT WAS AVAILABLE; IN EXPERIMENT 2, BALL FLIGHT INFORMATION WAS OCCLUDED. AS SUBJECTS VIEWED THE PITCH IN THE FIRST EXPERIMENT, THEY WERE TO DECIDE WHAT STROKE TO PLAY BY DEPRESSING A RESPONSE KEY. A TIMER RECORDED THE CORRESPONDING TIME. SUBJECTS ALSO QUICKLY GAVE VERBAL REPORTS ON WHAT STROKE THEY CHOSE AND WHERE THEY BELIEVED THE BALL WOULD LAND. THE SECOND EXPERIMENT WAS PROCEDURALLY IDENTICAL, BUT SUBJECTS WERE NOT UNDER ANY TIME CONSTRAINT WHEN RESPONDING. TWENTY VISUAL SIMPLE REACTION SCORES WERE ALSO RECORDED FOR EACH SUBJECT AT THE END OF THE STUDY. VIEWING TIME (VT) AND RESPONSE ACCURACY (RA) WERE THE TWO DEPENDENT MEASURES CALCULATED. VIEWING TIME WAS THE AMOUNT OF BALL FLIGHT OBSERVED PRIOR TO RESPONSE; RA WAS A THREE POINT INDEX COMBINING SUBJECT'S RESPONSE SELECTION WITH THE ACTUAL LANDING SPOT OF THE BALL. THE RA WAS EXPRESSED AS MEAN PERCENT CORRECT. A

3x2x6x8 (CLASS X BOWLER X BLOCKS X DELIVERY LENGTH) ANOVA WAS RUN ON THE TWO DEPENDENT VARIABLES WITH A TUKEY HSD BEING CONDUCTED ON SIGNIFICANT MEAN EFFECTS. THE RESULTS OF THE FIRST EXPERIMENT INDICATED A SIGNIFICANT DIFFERENCE BETWEEN THE THREE GROUPS IN TERMS OF RESPONSE ACCURACY ($F(2,15)=4.34$, $p < .05$). THE EXPERT GROUP MADE MORE ACCURATE PREDICTIONS ON BALLS PITCHED. ALL GROUPS WERE ALSO SHOWN TO MAKE MORE CORRECT PREDICTIONS IN LESS TIME AS A RESULT OF PRACTICE. SURPRISINGLY, SIGNIFICANT DIFFERENCES WERE NOT REVEALED BETWEEN GROUPS FOR SRT AND MEAN VT. EXPERIMENT 2 RESULTS REVEALED THAT ON AVERAGE THE HIGHLY SKILLED GROUPS MADE MORE ACCURATE RESPONSES BASED ON ADVANCED INFORMATION THAN DID BEGINNERS. THOUGH THE FINDINGS WERE IN THE DIRECTION HYPOTHESIZED, SIGNIFICANT FINDINGS WERE NOT REALIZED. THE AUTHORS SUGGESTED THAT PERHAPS EARLIER OCCLUSION POINTS MAY HAVE BROUGHT OUT THE DESIRED RESULTS.

HOWARTH ET AL. (1984) QUESTIONED THE ECOLOGICAL VALIDITY OF PREVIOUS STUDIES USING FILM-BASED TEMPORAL AND SPATIAL OCCLUSION METHODS FROM WHICH SUBJECTS HAD TO MAKE A VARIETY OF BALL FLIGHT JUDGMENTS. THE AUTHORS, THEREFORE, USED CINEMATOGRAPHY (100 FRAMES/SEC.) WHILE FILMING "LIVE" SQUASH MATCHES IN ORDER TO ANALYZE THE DIFFERENCE IN INITIAL ANTICIPATORY MOVEMENTS OF TWO LEVELS OF PLAYERS. A GENERAL MODEL FOR EXAMINING SPECIFIC "TIME PERIODS" DURING RAPID BALL SPORTS WAS DEVELOPED. THE MODEL COMPARED PLAYER'S OVERT MOVEMENT RESPONSES RELATIVE TO DISCRETE ENVIRONMENTAL EVENTS IN IDENTIFYING POTENTIAL ANTICIPATORY CUES/STIMULI. SUBJECTS, 2 EXPERT AND 2 LESSER SKILLED PLAYERS WERE FILMED FROM ABOVE THE COURT AS EACH PAIR PLAYED A MATCH, WITH 12 TRIALS BEING USED FOR ANALYSIS. A "TRIAL" CONSISTED OF THE TIME BETWEEN THE OFFENSIVE PLAYER'S MAKING BALL-RACQUET CONTACT AND THE DEFENDER'S RETURN CONTACT. FIVE EVENTS WERE

RECORDED ON EACH TRIAL: (1) OFFENSIVE PLAYER'S BALL CONTACT; (2) BALL-FRONT WALL CONTACT; (3) BALL-FLOOR CONTACT; (3) DEFENDER'S INITIAL ANTICIPATORY MOVEMENT TOWARD BALL; AND (4) DEFENSIVE PLAYER'S BALL CONTACT. ANTICIPATORY MOVEMENT WAS DEFINED AS THE FIRST OBVIOUS RESPONSE IN THE DIRECTION OF THE BALL (I.E., RAISING HEEL). THREE DEPENDENT MEASURES WERE CALCULATED ON EACH TRIAL: (A) TOTAL "TRIAL" TIME (TT); (B) TIME FROM DEFENDER'S ANTICIPATORY MOVEMENT TO BALL CONTACT (MT); AND (C) POINT 200 MS BEFORE DEFENDER'S FIRST ANTICIPATORY MOVEMENT (VT). THIS LAST MEASURE WAS AN ESTIMATE OF THE TIME WHEN INITIAL RESPONSE SELECTION WAS TERMINATED. T-TESTS WERE CONDUCTED TO COMPARE GROUPS ON TT AND ANTICIPATORY MOVEMENT INITIATION. RESULTS INDICATED THAT THE SPEED OF PLAY WAS SIMILAR IN BOTH GROUPS (TT; T=1.0), AND THAT HIGHLY SKILLED PLAYERS MADE ANTICIPATORY MOVEMENTS MUCH EARLIER THAN DID LESS SKILLED PLAYERS. THE SMALL VT VALUES SUGGESTED THAT EXPERT PLAYERS RELIED HEAVILY ON PRE-FLIGHT CUES WHEN MAKING ANTICIPATORY/RESPONSE DECISIONS WHILE NOVICE PLAYERS USUALLY DID NOT COMMIT THEMSELVES UNTIL LATER WHEN THE BALL WAS BETWEEN THEIR OPPONENT'S RACQUET AND THE FRONT WALL. SPECULATION AS TO POTENTIAL CUES USED BY EXPERTS INCLUDED THE FOLLOWING; (1) OPPONENT'S PREPARATORY ACTIONS; (2) RACQUET ANGLE AND SPEED AT CONTACT; AND (3) OPPONENT'S COURT POSITION.

A MAJORITY OF THE LITERATURE EXAMINING THE USE OF ADVANCED CUES BY NOVICE AND EXPERT PERFORMERS CAN BE SUMMARIZED AS REVEALING A SIGNIFICANT DIFFERENCE BETWEEN THE TWO GROUPS. THE EXPERIENCED GROUPS WERE SHOWN TO ATTEND TO OPPONENT'S MOVEMENTS OCCURING EVEN BEFORE BALL-RACQUET CONTACT (ABERNETHY & RUSSELL, 1984 & 1987; HOWARTH ET AL., 1984; JONES & MILES, 1978). EXPERTS ALSO DEMONSTRATED AN ABILITY TO GATHER MORE INFORMATION FROM THE EARLY PHASES OF OBJECT FLIGHT (ISAACS &

FINCH, 1983; ABERNETHY & RUSSELL, 1987). THIS CONCURRED WITH THE FINDINGS OF HUBBARD AND SENG (1954) AND WHITING, GILL, AND STEPHENSON (1970) WHICH BOTH INDICATED THAT A PLAYER DOES NOT HAVE TO WATCH THE BALL "ALL THE WAY IN" FOR SUCCESSFUL PERFORMANCE, THE EARLY STAGES OF FLIGHT PRODUCE MUCH RELEVANT INFORMATION. THIS EARLY DETECTION OF PERTINENT CUES WAS SHOWN TO AID PLAYERS IN THEIR RESPONSE INITIATION TO UPCOMING SHOTS/MOVEMENTS (HOWARTH ET AL., 1984).

Conclusions

The most common experimental procedure used when comparing the perceptual strategies of expert and novice performers was to film the situation from the receiver's perspective and require subjects to make predictions on the propelled object's landing position. The film usually had either spatial or temporal/spatial occlusions (Jones & Miles, 1978; Isaacs & Finch, 1983; Abernethy and Russell, 1984 & 1987). The particular part of the film occluded helped identify the specific part(s) of the display being attended to by the novice and expert, respectively; the relative time at which occlusion occurred (i.e., before or after ball-racquet contact) indicated the earliest point at which specific cues were being attended to by each group. Through the measurement methods above, expert performers have been shown to differ from beginners in terms of perceptual strategies. Some of the differences include the following:

(1) Experts attend to fewer, somewhat different visual cues than beginners. Although only limited research has been conducted identifying the exact cues utilized, it appears that experienced players gather the most critical information from the opponent's implement (e.g., racquet or stick) and arm most proximal to that implement (Abernethy & Russell, 1987a & b).

(2) Experts exhibit an ability to utilize advanced anticipatory cues and early flight cues during response preparation while novices focus on later flight cues for confirmation before responding (Salmela & Fiorito, 1979; Abernethy & Russell, 1987a

(3) Experienced players demonstrate earlier anticipatory movements during competition when compared to physically matched novices (Howarth et al., 1984). Experts seem to rely greatly on

ADVANCED INFORMATION IN MAKING RESPONSE DECISIONS.

(4) INCONSISTENCIES APPEAR REGARDING THE VISUAL SEARCH STRATEGIES USED BY EXPERTS AND NOVICES. SEVERAL AUTHORS (BARD & FLEURY, 1976; MOURANT & ROCKWELL, 1972) SUGGESTED THAT THE TWO GROUPS DIFFERED SIGNIFICANTLY IN TERMS OF SCAN PATHS (I.E., EXPERTS USE SHORTER AND FEWER FIXATIONS). ABERNETHY & RUSSELL (1987B) IN A MORE IN-DEPTH STUDY, CONTENDED THAT THE SAME GENERAL SEARCH SEQUENCES (I.E., PROXIMAL TO DISTAL) ARE USED BY PLAYERS AT BOTH LEVELS. BARD, FLEURY, & GOULET (1987) FURTHER SUGGESTED THAT THE REAL DIFFERENCE IN PERCEPTUAL STRATEGIES BETWEEN THE TWO SKILL LEVELS IS NOT IN THEIR PHYSICAL SEARCH PATTERNS, BUT IN THEIR RESPECTIVE ABILITIES TO CRITICALLY ATTEND TO AVAILABLE ENVIRONMENTAL INFORMATION.

APPLICATION OF THESE CONCLUSIONS TO PRACTICAL TEACHING COACHING SITUATIONS WOULD SEEM TO BE IN ORDER. INITIALLY, HOWEVER, A SYSTEMATIC WAY OF DETERMINING JUST WHAT THE RELEVANT CUES ARE SHOULD BE DEVELOPED. QUESTIONING AND TESTING ELITE ATHLETES ON THEIR ATTENTIONAL FOCUS APPEARS TO BE AT LEAST PART OF THE ANSWER.

SELECTED REFERENCES

ABERNETHY, B. & RUSSELL, D.G. (1984). ADVANCE CUE UTILISATION BY SKILLED CRICKET BATSMEN. *AUSTRALIAN JOURNAL OF SCIENCE AND MEDICINE IN SPORT*, *16*(2), 2-10.

ABERNETHY, B. & RUSSELL, D.G. (1987a). EXPERT-NOVICE DIFFERENCES IN AN APPLIED SELECTIVE ATTENTION TASK. *JOURNAL OF SPORTS PSYCHOLOGY*, *9*, 326-345.

ABERNETHY, B. & RUSSELL, D.G. (1987b). THE RELATIONSHIP BETWEEN EXPERTISE AND VISUAL SEARCH STRATEGY IN A RACQUET SPORT. *HUMAN MOVEMENT SCIENCE*, *6*, 283-319.

ALLARD, F. AND BURNETT, N. (1985). SKILL IN SPORT. *CANADIAN JOURNAL OF PSYCHOLOGY*, *39*(2), 294-312.

ANNETT, J. AND KAY, H. (1956). SKILLED PERFORMANCE. *OCCUPATIONAL PSYCHOLOGY*, *30*, 112-117.

BARD, C. AND FLEURY, M. (1976). ANALYSIS OF VISUAL SEARCH ACTIVITY DURING SPORT PROBLEM SITUATIONS. *JOURNAL OF HUMAN MOVEMENT STUDIES*, *3*, 214-222.

FITTS, P.M. (1964). PERCEPTUAL-MOTOR SKILLS LEARNING. IN A.W. MELTON (ED.), *CATEGORIES OF HUMAN LEARNING* (PP. 245-285). NEW YORK: ACADEMIC PRESS.

GENTILE, A.M. (1972). A WORKING MODEL OF SKILL ACQUISITION WITH APPLICATION TO TEACHING. *QUEST*, *17*, 3-23.

HASKINS, M.J. (1965). DEVELOPMENT OF A RESPONSE-RECOGNITION TRAINING FILM IN TENNIS. *PERCEPTUAL AND MOTOR SKILLS*, *21*, 207-211.

HOWARTH, C., WALSH, W.D., ABERNETHY, B., AND SNYDER, C.W., JR. (1984). A FIELD EXAMINATION OF ANTICIPATION IN SQUASH: SOME PRELIMINARY DATA. *AUSTRALIAN JOURNAL OF SCIENCE AND MEDICINE IN SPORT*, *16*(3), 7-11.

HUBBARD, A.W. AND SENG, C.N. (1954). VISUAL MOVEMENTS OF BATTERS. *RESEARCH QUARTERLY*, *25*, 42-57.

ISAACS, L.D. AND FINCH, A.E. (1983). ANTICIPATORY TIMING OF BEGINNING AND INTERMEDIATE TENNIS PLAYERS. *PERCEPTUAL AND MOTOR SKILLS*, *57*, 451-454.

JONES, C.M. AND MILES, T.R. (1978). USE OF ADVANCE CUES IN PREDICTING THE FLIGHT OF A LAWN TENNIS BALL. *JOURNAL OF HUMAN MOVEMENT STUDIES*, *4*, 231-235.

MOURANT, R.R. AND ROCKWELL, T.H. (1972). STRATEGIES OF VISUAL SEARCH BY NOVICE AND EXPERIMENTAL DRIVERS. *HUMAN FACTORS*, *14*(4), 325-335.

NOTON, D. AND STARK, L. (1971). EYE MOVEMENTS AND VISUAL PERCEPTION. SCIENTIFIC AMERICAN, 224, (6), 34-43.

POULTON, E.C. (1957). ON PREDICTION IN SKILLED MOVEMENTS. PSYCHOLOGICAL BULLETIN, 54(6), 467-478.

SALMELA, J.H. AND FIORITO, P. (1979). VISUAL CUES IN ICE HOCKEY GOAL TENDING. CANADIAN JOUENAL OF APPLIED SPORT SCIENCES, 4, 56-59.

SCULLY, D.M. AND NEWELL, K.M. (1985). OBSERVATIONAL LEARNING AND THE ACQUISITION OF MOTOR SKILLS: TOWARD A VISUAL PERCEPTION PERSPECTIVE. JOURNAL OF HUMAN MOVEMENT STUDIES, 11, 169-186.

WELFORD, A.T. (1968). FUNDAMENTALS OF SKILL. LONDON: METHUNE & CO. LTD.

WHITING, H.T.A. (1969). ACQUIRING BALL SKILL. PHILADELPHIA: LEA AND FEBIGER.

WHITING, H.T.A., GILL, E.B., AND STEPHENSON, J.M. (1970). CRITICAL TIME INTERVALS FOR TAKING IN FLIGHT INFORMATION IN A BALL-CATCHING TASK. ERGONOMICS, 13, 265-272.